Gulf of Mexico OCS Region

Technical Summary Specifications

Revision date: 03/98

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Technical Summary

PURPOSE

On November 22, 1985, the Associate Director for Offshore Minerals Management and the Branch of Environmental Studies of the Minerals Management Service (MMS) established specifications for the preparation of technical summaries by Environmental Studies Program (ESP) contractors. These standards have been revised on several occasions with this latest version dated March 1998. These summaries are required for annual reports of multi-year projects, final reports, and other major deliverable products that result from ESP contracts.

SPECIFICATIONS FOR PREPARATION OF TECHNICAL SUMMARIES

The following guidelines and specifications should be followed precisely. Any questions regarding the preparation of Technical Summaries should be addressed to the Contracting Officer's Technical Representative (COTR). The Technical Summary shall be approximately two (2) single-spaced printed pages in length, using 10-point Helvetica/Arial or Swiss font. A range of one and one-half (1-1/2) to three (3) single-spaced printed pages will be acceptable. Pages shall be 8 ½" by 11" white bond paper with print on one side only. Technical Summary text shall be prepared using WordPerfect 6.1 or later version. (Electronic versions of maps are not required.) The Technical Summary shall be prepared using the following elements:

- ACCESS NUMBER: (Upper Right, Each Page)
- **STUDY TITLE:**
- **REPORT TITLE:**
- CONTRACT NUMBER(S):
- SPONSORING OCS REGION:
- APPLICABLE PLANNING AREA(S):
- FISCAL YEAR(S) OF PROJECT FUNDING:
- COMPLETION DATE OF REPORT:
- COST(S): (BY FISCAL YEAR); CUMULATIVE PROJECT COST:
- PROJECT MANAGER(S):
- AFFILIATION (OF PROJECT MANAGER):
- ADDRESS:
- PRINCIPAL INVESTIGATOR(S)*:
- KEY WORDS:
- **BACKGROUND:**
- **OBJECTIVES:**
- **DESCRIPTION:**
- **SIGNIFICANT CONCLUSIONS:**
- **STUDY RESULTS:**
- **STUDY PRODUCT(S):**
- Map showing area of study

As shown above, all headings are in upper case letters and eight of the headings are in bold print. In addition, the access number is in bold print. The access number is placed in the upper right-hand corner of

each page of the Technical Summary, including the map. This number is comprised of the last five digits of the MMS contract number. When a contract results in several reports that are to be summarized separately, the access number should include a decimal followed by sequential numbers for each Technical Summary. For example, MMS contract number 14-12-0001-30037 resulted in six final products that were summarized separately. Numbering should reflect the natural (Vol. 1, 2, 3) or chronological (Year 1, 2, 3) order of the reports. The access numbers for those six summaries are listed below:

30037	30037.2	30037.3
30037.4	30037.5	30037.6

An endnote should be placed at the bottom of the last page of text, following conclusion of the "STUDY PRODUCT(S)" element, and should appear on all Technical Summaries for consistency. An asterisk is placed after the "PRINCIPAL INVESTIGATOR(S)" element for reference to the endnote. Sample Technical Summaries are attached for reference to placement of all elements. The endnote is worded as follows:

* P.I.'s affiliation may be different than that listed for Project Manager(s).

The purpose of the map is to provide the reader with a quick reference of the location of the study. The map shall be on a separate page from the text. Major reference points on land (cities, state boundaries, etc.) and offshore features (canyons, banks, etc.) shall be labeled. Latitude and longitude, bathymetric contours at 200 and 2,000 meters water depth, and map scale shall be provided on each map. An inset map shall be used to show the areas of study in reference to an entire OCS Region. To insure consistency in the appearance of Technical Summaries, appropriate base maps should be requested from the COTR. It is recognized that maps may not be appropriate for some Technical Summaries. For example, a Technical Summary prepared for a report based on a laboratory study with generic application of results to all OCS areas would not require a map. The COTR for each study will make the determination concerning the inclusion of a map as part of the Technical Summary. Additional editorial and style specifications should be consistent with the attached examples of completed Technical Summaries.

Additional Technical Summary Specifications for Deliveries/Performance

The following guidelines represent a minimum distribution requirement for Headquarter's needs relative to Technical Summaries. The Gulf of Mexico OCS Region requires additional distribution of Technical Summary products as shown:

- Draft Technical Summary: Submit two (2) copies to Chief, Environmental Studies Branch (MS 4041), Gulf of Mexico OCS Region, two (2) copies to COTR (MS 5430).

- Final Technical Summary: Submit five (5) copies and diskette to Chief, Environmental Studies Branch (MS 4041). Gulf of Mexico OCS Region, five (5) copies to COTR (MS 5430).

- The scheduling for Technical Summary deliverables and their review should generally coincide with the scheduling of the draft and final reports. The COTR may establish an alternate schedule to expedite completion of the Technical Summary. The Gulf of Mexico OCS Region requires these to be submitted with the Draft and Final Reports.

ACCESS NUMBER: **30188**

STUDY TITLE: Florida Big Bend Sea Grass Habitat Study.

REPORT TITLE: Florida Big Bend Seagrass Habitat Study.

CONTRACT NUMBER(S): MMS: 14-12-0001-30188.

SPONSORING OCS REGION: Gulf of Mexico.

APPLICABLE PLANNING AREA(S): Eastern Gulf of Mexico.

FISCAL YEAR(S) OF PROJECT FUNDING: 1984; 1985; 1986.

COMPLETION DATE OF REPORT: December 1985.

COST(S): FY 1984: $261,201; FY 1985: $70,000; FY 1986: $54,745; CUMULATIVE PROJECT COST: $385,946.

PROJECT MANAGER(S): T. Kunneke, M. Thompson.

AFFILIATION: Continental Shelf Associates, Inc.

ADDRESS: 759 Parkway Street, Jupiter, Florida 33477.

PRINCIPAL INVESTIGATOR(S)*: T. Kunneke, M. Thompson.

KEY WORDS: Eastern Gulf; Florida Big Bend; biology; seagrasses; inventory; maps; aerial photography; survey; photographimetric technique; benthic photographs; habitat; zonation; hard-bottom.

BACKGROUND: The crescent-shaped portion of Florida's west coast from Ochlockonee Bay south to Tarpon Springs is referred to as the Florida Big Bend. The expanse of continental shelf area within the Florida Big Bend is important to fisheries and environmental interests. When this area became the focus of oil and gas developers, the State of Florida indicated that the lack of information on live-bottom and seagrass distribution within the area would not permit responsible management of exploratory activities. Consequently, the U.S. Department of the Interior initiated the Florida Big Bend Seagrass Study to provide supporting data for development of biological stipulations and evaluation of lease block specific plans of exploration or development.

OBJECTIVES: (1) To inventory and map seagrass beds in the Florida Big Bend area by combining aerial remote sensing and extensive ground truthing data; (2) To determine the seaward extent of major seagrass beds within the study area; and (3) To classify and delineate major ecological habitat types in the study area.

DESCRIPTION: The study area encompassed approximately 1.5 million ha of seafloor extending from the coastline to the 20-m isobath. The study was conducted in three parts: (1) a pre-overflight ground truthing cruise; (2) a remote sensing overflight encompassing the study area; and (3) a post-overflight ground truthing cruise to verify interpretation of remote sensing data. During the first cruise (Cruise 1) conducted from 24 October to 1 November 1984, 1,232 km of seafloor between the 10- and 20-m depth contours were surveyed using a towed underwater television system. Navigational fixes consisting of Loran-C time delays and bottom-type descriptions were recorded at 5-min intervals along the transects. Additionally, 50 signature control stations ranging in water depths from 3 to 23 m were established to assist aerial photographic interpretation in locations of known seagrass coverage. At each station, large floating targets were deployed; divers then took quantitative (343.6 cm^2) and qualitative 35-mm e seafloor under the targets to estimate seagrass density and species composition. Aerial overflights were made between 30 October and 15 November 1984 along 26 north-south flight lines. Photographs were taken using 23 cm x 23 cm color print film. The scale on all photographs was 1:40,000. During Cruise 2 conducted from 19 to 27 February 1985, nine additional transects (174 km) were surveyed using towed divers and underwater television. Eleven of the 50 signature control stations established during Cruise 1 were resampled using the same methods employed during the earlier cruise. Aerial photographs were analyzed

stereoscopically, and seagrass beds were classified by density (dense, sparse, and patchy). Due to signature similarities between seagrass beds and low relief coral, sponge, and gorgonid assemblages frequently seen between them, live bottom could not be differentiated from seagrass habitat at the 1:40,000 imagery scale.

SIGNIFICANT CONCLUSIONS: Within the Florida Big Bend study area, 16% of the area was described as dense seagrass beds, 33% as sparse seagrass beds, and 19% as patchy seagrass beds. Seagrass associations occurred in two general zones based on depth. In waters shallower than 10 m, dense associations of turtle grass, manatee grass, and shoalgrass provided dense images in the aerial photography. Seaward of this zone, sparse associations of seagrasses, macroalgae, and live bottom were identified extending to at least the 23-m depth contour. The extended nature of this sparse, offshore zone was considered a unique feature of the Florida Big Bend area zonation pattern. Seasonal variation in seagrass blade density and species composition was observed at the offshore signature control stations. Little information is available concerning the ecology of the fringing zone seagrass beds of the Florida Big Bend area.

STUDY RESULTS: Approximately 1.5 million ha were mapped during overflights of the Florida Big Bend study area. Two maps were produced: one at 1:40,000 scale and another at 1:250,000 scale. The second map was a composite, produced to be superimposed on existing Minerals Management Service Protraction Diagrams. Results from combined aerial mapping and ground truthing delimited 232,893 ha of dense seagrass beds; 498,034 ha of sparse seagrass beds; and 279,722 ha of patchy seagrass beds within the study area.

On a broad scale, the Florida Big Bend seagrass stands exhibited zonation typical of southern Florida or Caribbean seagrass beds. An inshore association of turtle grass (Thalassia testudinum), manatee grass (Syringodium filiforme), and shoalgrass (Halodule wrightii) occurred in water depths less than 10 m. Turtle grass and manatee grass formed dense beds that were easily detected by aerial photographs. At the seaward margin of these dense beds, an overlap area consisting of five species (manatee grass, turtle grass, and shoalgrass, as well as Halophila decipiens and H. engelmanni) was detected. Offshore, from 10 m out to at least 23 m a sparse fringing zone occurred. This zone was composed of a mixed association of seagrasses, macroalgae, and live bottom. The only true seagrasses present were the Halophila species.

Blade density determined from the nearshore association ranged from 41 to 309 blades m^{-2}. In the offshore association, blade densities ranged from 374 to 2,657 blades m^{-2}. Blade density was not indicative of bottom coverage by seagrasses within the two zones. Blade densities at 9 of the 11 signature control stations resampled during Cruise 2 were 50 to 90% lower and H. decipiens was completely absent. Temperature, light, and wave action probably contributed to the observed spatial and seasonal patterns in the grass beds.

STUDY PRODUCT(S): Continental Shelf Associates, Inc. and Martel Laboratories, Inc. 1985. Florida Big Bend Seagrass Habitat Study. A final report for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, Metairie, LA. Contract No. 14-12-0001-30188. 89 pp.

Continental Shelf Associates, Inc. and Martel Laboratories, Inc. 1985. Florida Big Bend Seagrass Habitat Study Photographic Atlas. A final report for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, Metairie, LA. Contract No. 14-12-0001-30188. 6 pp. + 557 plates.

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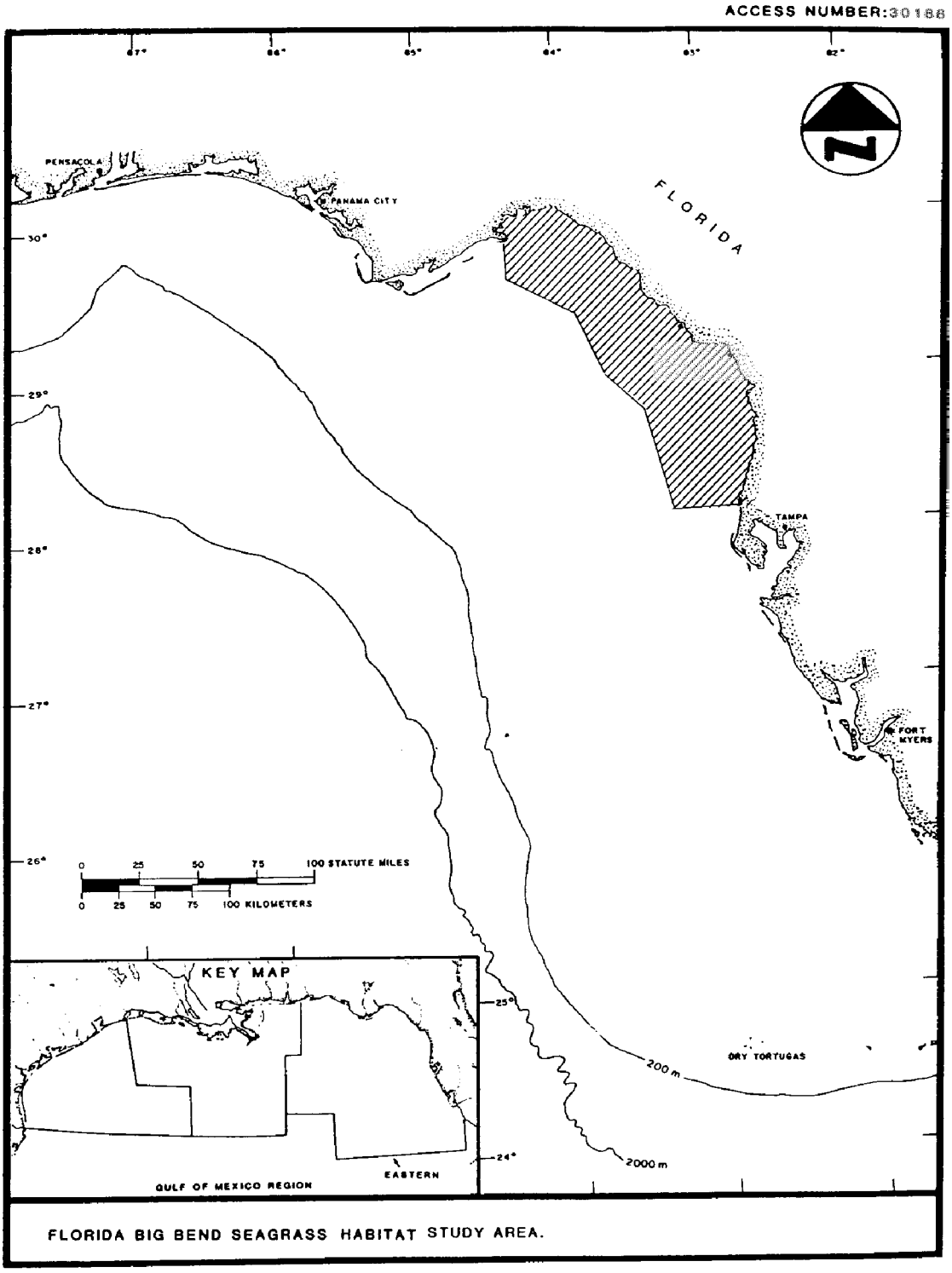

FLORIDA BIG BEND SEAGRASS HABITAT STUDY AREA.

STUDY TITLE: Assessment of Long-Term Changes in the Biological Communities in the Santa Maria Basin and Western Santa Barbara Channel (Year I).

REPORT TITLE: Assessment of Long-Term Changes in Biological Communities of the Santa Maria Basin and Western Santa Barbara Channel - Phase I. Vol. I, Executive Summary; Vol. II, Synthesis of Findings.

CONTRACT NUMBER(S): MMS: 14-12-0001-30032.

SPONSORING OCS REGION: Pacific.

APPLICABLE PLANNING AREA(S): Central and Northern California; Southern California.

FISCAL YEAR(S) OF PROJECT FUNDING: 1983; 1984; 1985.

COMPLETION DATE OF REPORT: February 1986.

COST(S): FY 1983: $500,000; FY 1984: $908,472; FY 1985: $100,093; CUMULATIVE PROJECT COST: $1,508,565.

PROJECT MANAGER(S): A. Lissner, R. Shokes.

AFFILIATION: Science Applications International Corporation.

ADDRESS: 476 Prospect Street, La Jolla, California 92037.

PRINCIPAL INVESTIGATOR(S)*: W. Anikouchine, B. Bernstein, D. Cadien, R. Cimberg, R. Kanter, T. Kauwling, A. Lissner, J. Payne, C. Phillips, R. Shokes, R. Sims, R. Smith.

KEY WORDS: Central and Northern California; Southern California; Point Estero; Santa Barbara Channel; Santa Maria Basin; biology; benthos; habitat; community; sediment; hydrocarbons; trace metals; hard-bottom; photographs; grain size; gas chromatography; submersible; videotapes; observations; benthic photographs; epifauna; infauna; photographimetric technique; maps; shelf; slope.

BACKGROUND: The Santa Maria Basin and Western Santa Barbara Channel of Southern California are slated for extensive oil and gas development. The U.S. Department of the Interior is responding to this anticipated offshore activity by sponsoring a three-phase program designed to monitor long-term changes in the benthic environment related to operational or accidental oil and gas related inputs. This report contains the first-phase results regarding background levels of sediment hydrocarbon and trace metal concentrations and recommendations for future monitoring sites.

OBJECTIVES: (1) To identify and map benthic habitats and biological assemblages; (2) To describe any new benthic species; (3) To characterize existing sediment hydrocarbon and trace metal levels; and (4) To identify candidate sites and species for future long-term monitoring studies.

DESCRIPTION: Soft-bottom and hard-bottom surveys were conducted from November 1983 to January 1985. Soft-bottom surveys included sampling at 107 stations located along 16 transects. Sediments were collected using a Teflon and stainless steel coated 0.1-m^2 box corer and a 0.1 m^2 Van Veen grab sampler. One to three replicates were taken at each station (nine replicates were taken at one station to assess within core variability). Color 35-mm photographs were taken of the surface and sides of the core. Samples for chemical, geological, and physical analysis were extracted from each core sample. Trace metal samples were collected using Teflon utensils and frozen. Hydrocarbon samples were collected using hexane washed glass jars with Teflon lids. A Plexiglas tube was used to sample for sediment grain size.

Sediment cohesiveness was measured using a torsional vane shear device. The remainder of the sample was sifted through a high volume, low pressure, tiered, sieving device with 5.0-mm, 1.0-mm, and 0.5-mm openings. All specimens were relaxed in magnesium sulfate then preserved in formalin.

In the laboratory, infaunal samples were sorted into annelids, crustaceans, echinoderms, mollusks, and other groups. Organisms within each group were wet weighed and counted. Selected species were measured. Samples for hydrocarbon analysis were fractionated into polar, saturated, and aromatic compounds, then analyzed using a gas chromatograph with flame ionization detector. The data obtained were used to determine values for the following parameters: total hydrocarbons, total aromatics, total alkanes and saturates, total unresolved components, pristine/phytane ratio, pristane/nC^{17} ratio, phytane/nC^{18} ratio, odd alkanes/even alkanes ratio, and unresolved/resolved complex ratio. Barium and chromium from the sediments were detected using instrumental neutron activation analyses. Total organic carbon in sediments was estimated with a carbon analyzer. Grain size analyses were performed by settling tube and reported in phi units. Hard-bottom surveys were conducted at selected locations of the Santa Barbara Channel and Santa Maria Basin. Manned submersible dives were made along 23 transects representing 15 stations extending from near Gaviota to Pt. Estero, California. Survey depths ranged from 60 to 240 m with an average of 100 to 130 m. Data collected from these areas consisted of color videotapes, direct observations, and 35-mm still photographs. Still photographs were analyzed for species composition, percent epifaunal cover, substrate type, percent sediment cover, and relief. Only slides where distance and area covered could be accurately estimated were used for quantitative estimations. Data values for measured variables (grain size, trace metals, hydrocarbons, and total organic carbon) were plotted on a computer-generated map of the study area. Statistical analyses of soft-bottom and hard-bottom data consisted of ordination, cluster, and discriminant analyses. Ecological distance measure was employed as a multivariate measure of biological change. Power tests were used to determine sample sizes required to detect a 50% change from observed background levels.

SIGNIFICANT CONCLUSIONS: Soft-bottom communities were distributed primarily by depth but some north-south trends were evident. The numerically dominant organisms were polychaete worms, followed by echinoderms. Comparisons with the literature indicate little change in soft-bottom community composition over the last six years on the shelf; slope communities exhibited some changes. Submersible observations revealed three hard-bottom assemblages and one soft-bottom assemblage. Hard-bottom communities were dependent on depth and available substrate. Sessile invertebrates such as anemones, cup corals, and hydroids were considered most vulnerable to impacts from drilling-related discharges. Trace metal levels in sediments were associated with proximity to input sources, both anthropogenic or natural. Potential sources of hydrocarbons were seeps, erosion of oil-bearing shales, shipping losses, tanker operations, atmospheric deposition, oil and gas operations, discharges of municipal and industrial waste waters, and deposition of allochthonous (terrestrial plants) and autochthonous biogenic sources. Certain hydrocarbon concentrations in bottom sediments were correlated with fine bottom sediments.

STUDY RESULTS: The soft-bottom assemblage of the inner shelf was numerically dominated by polychaetes, while heart urchins dominated biomass values. Soft-bottom biological assemblages of the outer shelf were numerically dominated by ophiuroids and other echinoderms. Of the 996 soft-bottom taxa collected, 20% were previously undescribed. The commercially important spot prawn occurred in the study area but was not taken in appreciable quantities. Clustering discerned six major and five secondary site groups, mostly separated by water depth. At shelf and mid-slope depths, the number of species and individuals per sample decreased with increasing depth. Hard-bottom features were recorded on 17 of 23 transects; only five of the transects exhibited outcrop areas comprising >90% of the transect. Sediment cover was extensive on most of the transects. Substrate relief was generally low (0 to 1 m) over most transect areas. Some areas exhibited medium to high relief. The occurrence and development of hard-bottom animal communities depended on substrate relief and availability. Numerically dominant invertebrate taxa identified from photographs included echinoderms (33 taxa) and coelenterates (31 taxa). Three hard-bottom assemblages were identified: a generalist assemblage characterized by anemones, crinoids, cup corals, and sea stars occurring throughout the range of depths encountered during the study; a low/medium relief assemblage characterized by ophiuroids, brachiopods, and anemones typically occurring in lower relief areas; and a high to medium relief assemblage characterized by few taxa including anemones, corals, and other generalist taxa.

Three main sediment types were recognized in the study area: Santa Lucia Bank sediment comprised of oxidized mud containing phosphorite grains and medium to fine grained sand with low organic content; continental shelf sediment in depths less than 120 m consisting of mud with fine sand, low clay content, high sand content, and low organic carbon content; and continental slope sediment occurring at depths below 120 m characterized by olive green mud with high clay and silt content, low sand content, and high organic carbon content. Ranges of sediment concentration of barium and chromium were 162 to 1,180 ug g dry wt^{-1} and 66 to 415 ug g dry wt^{-1}, respectively. Total sediment hydrocarbon levels ranged from 1.2 to 166 ug g dry wt^{-1}. Aromatic hydrocarbons in sediments ranged from 0.38 ug g dry wt^{-1} to 78 ug g dry wt^{-1}. Relatively higher levels
occurred at stations in the nearshore areas south of Pt. Conception, within the Santa Barbara Basin, in the Arguello submarine canyon, and in the sea valley east of Santa Lucia Bank. These stations are apparently near natural petroleum seeps. Total organic carbon in sediments ranged from 0.36% to 3.4%.

STUDY PRODUCT(S): Lissner, A., C. Phillips, D. Cadien, R. Smith, B. Bernstein, R. Cimberg, T. Kauwling, and W. Anikouchine. 1986. Assessment of Long-Term Changes in Biological Communities of the Santa Maria Basin and Western Santa Barbara Channel - Phase I. Vol. I, Executive Summary. A final report by Science Applications International Corporation for the U.S. Department of the Interior, Minerals Management Service Pacific OCS Region, Los Angeles, CA. NTIS No. PB86-240363. Contract No. 14-12-0001-30032. 33 pp.

Lissner, A., C. Phillips, D. Cadien, R. Smith, B. Bernstein, R. Cimberg, T. Kauwling, and W. Anikouchine. 1986. Assessment of Long-Term Changes in Biological Communities of the Santa Maria Basin and Western Santa Barbara Channel - Phase I. Vol. II, Synthesis of Findings. A final report by Science Applications International Corporation for the U.S. Department of the Interior, Minerals Management Service Pacific OCS Region, Los Angeles, CA. NTIS No. PB86-240371. Contract No. 14-12-0001-30032. 471 pp.

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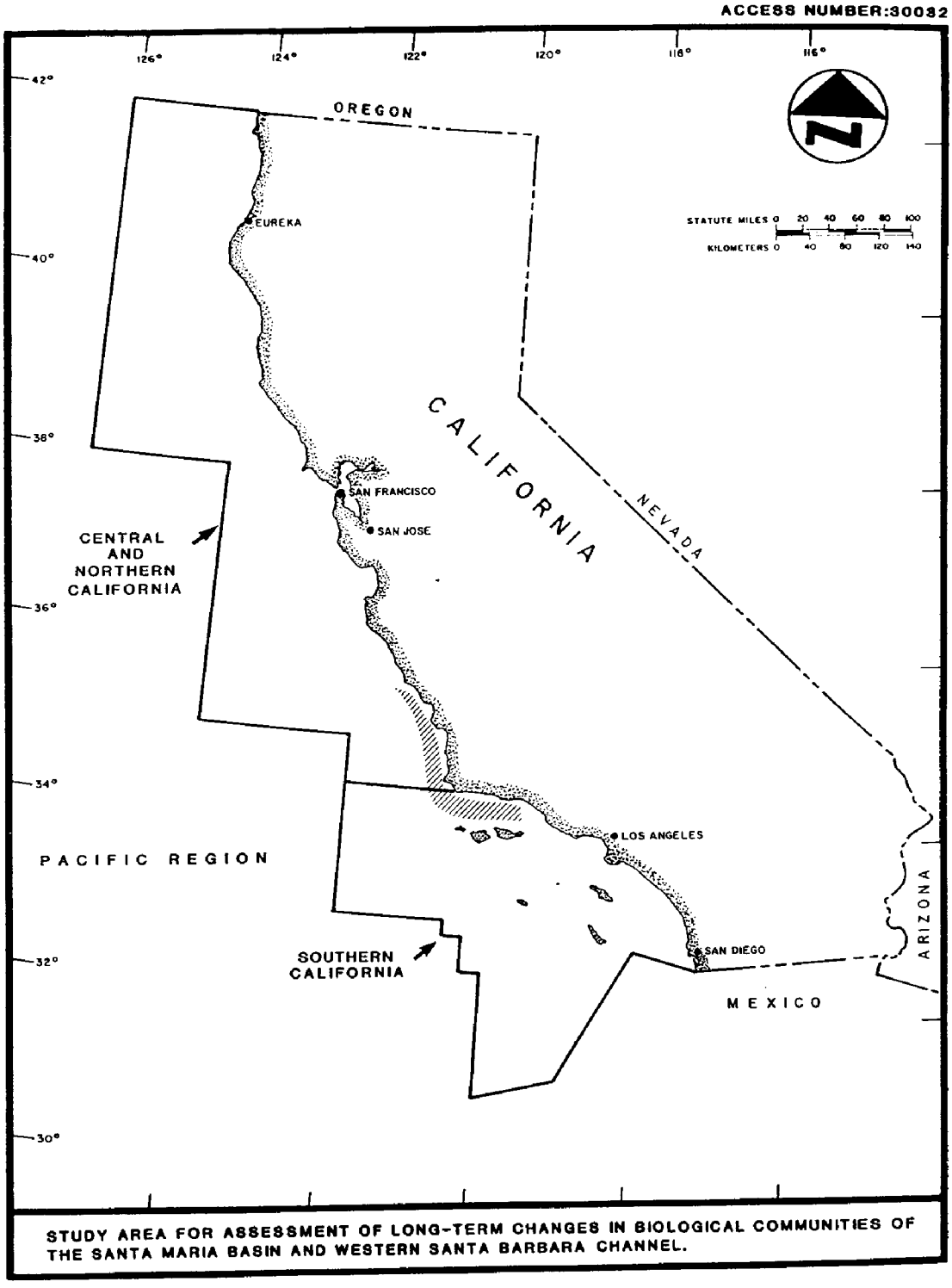

STUDY AREA FOR ASSESSMENT OF LONG-TERM CHANGES IN BIOLOGICAL COMMUNITIES OF THE SANTA MARIA BASIN AND WESTERN SANTA BARBARA CHANNEL.

STUDY TITLE: Conference and Reports on Minerals Management Service Results.

REPORT TITLE: Forage Fishes of the Southeastern Bering Sea. Conference Proceedings.

CONTRACT NUMBER(S): MMS: 14-12-0001-30297.

SPONSORING OCS REGION: Alaska.

APPLICABLE PLANNING AREA(S): Aleutian Arc; North Aleutian Basin; St. George Basin; St. Matthew Hall; Bowers Basin; Aleutian Basin; Navarin Basin; Norton Basin.

FISCAL YEAR(S) OF PROJECT FUNDING: 1986; 1987; 1988; 1989.

COMPLETION DATE OF REPORT: July 1987.

COST(S): FY 1986: $45,837; FY 1987: $87,780; FY 1988: $60,213; FY 1989: $250,000; CUMULATIVE PROJECT COST: $443,830.

PROJECT MANAGER(S): C. Mitchell.

AFFILIATION: MBC Applied Environmental Sciences.

ADDRESS: 947 Newhall Street, Costa Mesa, California 92627.

PRINCIPAL INVESTIGATOR(S)*: C. Mitchell.

KEY WORDS: Aleutian Arc; North Aleutian Basin; St. George Basin; St. Matthew Hall; Bowers Basin; Aleutian Basin; Navarin Basin; Norton Basin; Alaska; forage fish; workshop; synthesis; population; dynamics; seasonality; habitat; Bering Sea; trophic dynamics; pollock; Theragra; herring; smelt; salmon; larval stages; mortality; commercial fishing; Alaska Region.

BACKGROUND: The Alaskan Bering Sea produces a sizeable fraction of the world's annual harvest of seafoods, with major fisheries for salmon, shellfish, and groundfish. The anticipation of oil and gas lease sales in the southeastern portion of the Bering Sea has prompted the need for a greater understanding of the interrelationships of the various components of this ecosystem. Since 1974, the Outer Continental Shelf Environmental Assessment Program (OCSEAP) has sponsored studies of the many Bering Sea ecosystem components. These OCSEAP study efforts have been administered by the National Oceanic and Atmospheric Administration with funding provided by the U.S. Department of the Interior, Minerals Management Service (MMS). Recent syntheses of these studies have identified needs for further understanding the importance of forage fishes, which are abundant, small, schooling fishes that serve as prey for many species of fish, seabirds, and marine mammals. Because of their importance in the Bering Sea ecosystem, the MMS Alaska OCS Region sponsored a conference on Forage Fishes of the Southeastern Bering Sea.

OBJECTIVES: (1) To synthesize information on the population dynamics, seasonal movements, and habitat requirements of forage fishes in the southeastern Bering Sea for use in environmental assessment and studies planning related to oil and gas exploration.

DESCRIPTION: Forage fishes play an important part in the Bering Sea ecosystem. For this reason, MMS Alaska OCS Region sponsored a conference on Forage Fishes of the Southeastern Bering Sea. MMS, with the assistance of MBC Applied Environmental Services, invited 12 fisheries experts to address a group of about 50 scientists and managers actively engaged in the study or management of the biological and mineral resources of the subarctic environment. The attendees included representatives of Federal, State, and local government agencies, private companies, commercial fishing organizations, and academic institutions of both the U.S. and Canada. There were two major themes considered during the conference: papers focusing on forage fish trophic interactions in the southeastern Bering Sea, followed by a discussion on predator-prey relationships in the coastal environment of this region; and the dynamics of fisheries oceanography and forage fish, followed by a discussion on the dynamics of coastal fisheries oceanography and the distribution and relative abundance of forage fish along the north shore of the Alaska Peninsula.

This report includes a series of short papers prepared by the group of invited technical experts, followed by brief summaries of the subsequent discussion sessions.

SIGNIFICANT CONCLUSIONS: Major forage fishes of the southeastern Bering Sea include the walleye pollock (Theragra chalcogramma), Pacific herring (Clupea pallasii), capelin (Mallotus villosus), Pacific sand lance (Ammodytes hexapterus), and rainbow smelt (Osmerus mordax). Most of these species exhibit schooling behavior, have relatively short life spans, short maximum lengths, and locally become very abundant. Forage fishes and the demersal eggs of forage fishes are prey to marine mammals, seabirds, and larger bony fishes in the southeastern Bering Sea. Walleye pollock is one of the most important species in the commercial trawl fishery of the southeastern Bering Sea. The Pacific herring is the target of a purse seine and gillnet fishery for sac roe, and an intertidal fishery for eggs-on-kelp. Capelin could be a target of a commercial fishery in the future. The most important forage fishes for future study include the Pacific herring, capelin, and Pacific sand lance. The most sensitive species to environmental perturbation are the Pacific herring and capelin, which both have relatively specialized intertidal or shallow subtidal spawning sites. The most important areas, in terms of being crucial to populations of forage fishes in the Bering Sea, include Togiak Bay and Port Moller. Predation is believed to be the most important factor controlling the abundance of forage fishes. Physical variation in the environment is believed to play a relatively minor role. Relatively little is known about the biology of most forage fish species (other than walleye pollock) found in the region. Therefore, future studies should focus on the determination of abundance, population dynamics, movements, trophic relationships, and on describing habitat, environmental requirements, early life history, and spawning location.

STUDY RESULTS: The symposium included the following papers: Dynamics of the Southeastern Bering Sea Oceanographic Environment; The Bering Sea Ecosystem as a Predation Controlled System; Marine Mammals and Forage Fishes in the Southeastern Bering Sea; Trophic Interactions Between Forage Fish and Seabirds in the Southeastern Bering Sea; Demersal Fish Predators of Pelagic Forage Fishes in the Southeastern Bering Sea; Dynamics of Coastal Salmon in the Southeastern Bering Sea; Forage Fishes in the Shallow Waters of the North Aleutian Shelf; Population Dynamics of Pacific Herring (Clupea pallasii), Capelin (Mallotus villosus), and Other Coastal Pelagic Fishes in the Eastern Bering Sea; The History of Pacific Herring Fisheries in Alaska; Environmental-Dependent Stock-Recruitment Models for Pacific Herring (Clupea pallasii); and Atlantic Herring (Clupea harengus) Movement along the Scotian Shelf and Management Considerations.

Generally, conference participants considered the major forage species in the southeastern Bering Sea to include walleye pollock, Pacific herring, rainbow smelt, Pacific sand lance, and capelin, although other species including juvenile salmon and benthic fishes are also important. Major high-level mammalian predators in the southeastern Bering Sea ecosystem include northern fur seal, harbor seal, Steller sea lion, and belukha whale. Seabirds predators in the system include shorttail shearwater, common murre, thick bill murre, black-legged kittiwake, and tufted puffin. It was felt that in the event of a major decline in the stock size of a specific forage fish species, some or most predator species would be able to switch to other forage species. It was not known, however, the effect of such a change on their biology without understanding more about the nutritional value of the prey species. It was felt that the standing stock, or total biomass of predators should not be the only criterion used for judging the importance of predation because of seabirds, which have a small standing stock and greater conversion rates than marine mammals, which have a large standing stock.

The strength of a particular year class (cohort) can be determined by the degree to which its abundance differs from the average expected abundance of a cohort of a given age. A strong year class is apparent as a peak in the age or size composition of a population, which appears to be apparent in successive years at successive ages. Year-class strength can be affected by physical and biological variables within the environment. Mortality in marine fishes occurs primarily in the egg stage (about 98%); life history strategies of the fishes are generally adapted to cope with the intense mortality at this period. Mortality during the larval

and early juvenile stages is often most crucial in determining the strength of a year class, as a change in the mortality rate of 10% or more could have a major effect on a given population. It was thought that within the southeastern Bering Sea, predation is the most important factor affecting the year class strength of forage fishes. The effects of predation within the region are primarily local, and it was felt that the individual effects of predation by mammals, seabirds, and from commercial fishing pressure are difficult to separate. Other biological parameters are difficult to document in the field, and the effects of physical parameters, such as current patterns, temperature regimes, ice cover, wind direction, and runoff are thought to have little effect on year-class strength, although they could affect the timing of spawning. It was felt that the best way to forecast year-class strength would be to do pre-recruit studies, possibly through the examination of predator stomach contents. Certain life history traits of pelagic forage fishes make them susceptible to predation or environmental perturbations, such as schooling behavior, which facilitates predation by marine mammals, and littoral spawning habits (such as the Pacific herring and capelin), which might make them vulnerable to unusual beach disturbances such as oil spills.

The rank of forage fishes in the southeastern Bering Sea region, with respect to their importance as prey, significance to commercial fisheries, and the current knowledge of their life history, was as follows: (1) walleye pollock, (2) Pacific herring, (3) capelin, and (4) Pacific sand lance. It was felt that squid, which was not covered in this conference, could be of equal or greater importance as prey as any of the aforementioned forage fishes in the region. When ranking the forage fish species with respect to their sensitivity to environmental perturbation, the order was as follows: (1) Pacific herring, (2) capelin, (3) Pacific sand lance, and (4) walleye pollock. It was felt that the most sensitive area in the region, in terms of potential effects of human activities on forage fishes, is Togiak Bay, which is presently an important spawning area for Pacific herring, and followed by Port Moller, on the Alaska Peninsula.

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